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THE UTILIZATION OF HONEY IN BAKED PRODUCTS[1]

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Honey was used as early as 3000 B.C. in the courts of Pharaoh. It has continued throughout the history of civilized man to command a respected place among the many foods that man consumes. Even today, honey need not take a secondary place as a sugar source, even though more modern means of satisfying man's demand for sweeteners are readily available.

Potential Markets

The people of the United States consume great quantities of sugar or syrups. The canning industry utilizes more than 300 million pounds, the confectionery industry 500 million pounds, the soft drink industry 600 million pounds, and the baking industry more than 1 billion pounds of sugar annually. The annual per capita consumption of refined sugar in 1953 was 96.8 pounds*. In round numbers, the people of the United States consumed about 16 billion pounds of refined sugar in 1953. In addition to refined sugar, approximately 165 million gallons of edible syrup including maple, corn and honey were consumed[3]. Consumption of honey, in 1953, was estimated to be 17 million gallons. Total honey production and imports amounted to approximately 20 million gallons*. These statistics are good indicators of the potential markets for sweetening agents in the United States.

Let us examine more closely the potential market for sweetening agents in the baking industry of the United States. The production and quantity of sugar used for each major type of bakery product in the United States in 1947 are shown in **Table I.** The total consumption of sugar exceeded 1.5 billion pounds, annually. The sugar used in these products has been calculated, assuming an average product formula.

The largest production item of the baking industry is bread. However, sweet goods utilize percentagewise almost three times as much sweetening agent.

While it must be recognized that honey is not satisfactory for all types of baked products, there are some products in which honey fills a particular need. Investigations were made by the authors to discover the particular baked products that were improved by the use of honey. Associated problems included the relationship of floral source and chemical analysis to the use of honey in baked products, the effect of high concentration of honey on the browning of cake crumb and the use of honey in various icings. These problems are discussed briefly in this paper.

Sources of Honey

Honey is a natural product and may be expected to have more variations in properties than other forms of sweeteners. It is known to vary with respect to moisture, color, flavor, acidity, and ratio of levulose to dextrose. Fifteen honeys were selected as being representative of the most abundantly available flavors or floral sources. Their chemical analyses are presented in **Table II.** The variation in moisture, color, total acidity and sugar content will be noted (1).

Use of Honey

The 15 floral sources of honey were used as substitutes for sugar in white, whole wheat and rye breads. For white bread, the concentration of honey ranged from three to six per cent while for whole wheat and rye bread it was increased to as high as 12 per cent. Honey can be substituted for sugar in bread production at normal levels without any appreciable effect on the steps of the breadmaking process. However, it had several noticeable effects on the quality of bread. The color intensity of white bread crumb was proportional to the color intensity of the honey. Thus, dark colored honeys such as buckwheat, fall flowers, and heartsease, are not desirable for white bread production. However, they may be blended in small concentrations with light colored honeys. Variations in moisture, acidity or sugar content of the honey did not appreciably affect the quality of the bread.

It has been a popular belief that honey improves the moisture retention of bread crumb and, therefore, is an aid in retention of freshness. Experiments failed to support this hypothesis.

Consumer acceptability tests demonstrated that various honeys affect the aroma and taste of bread. At a six-per cent level of honey in white bread, 69 per cent of the consumers could detect the presence of honey. Twenty-one per cent of the reactions were regarded as unpleasant and of these 62.5 per cent were due to

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Table I

Quantity of baking products produced and sugar consumed in the United States in 1947[1].

Type of Produce	Quantity Millions of lbs.	Sugar Used Millions of lbs.
Breads:		
White pan	8,500	300
White Hearth	306	4
Whole Wheat	893	20
Rye	613	8
Raisin	193	4
Miscellaneous	200	4
Total	10,705	340
Sweet Goods:		
Rolls, bread	943	56
Rolls, sweet	612	30
Doughnuts	310	15
Cakes	1,210	500
Pies	601	200
Cookies	1,800	300
Total	5,476	1,101

[1] Census of Manufacturers; Statistics by Industries. Vol. II, pp. 116 (1949).

strong flavored honeys such as buckwheat, fall flowers, and heartsease. The aroma of honey is particularly pronounced when bread is toasted.

The problems of using honey in whole wheat and rye bread are not so great as in those of white bread because color is not a problem in the dark breads. Honey imparted a richness of flavor to both whole wheat and rye bread. Pure floral sources of buckwheat, heartsease, fall flowers, and horsemint are not recommended for production of dark bread. These honeys can be blended with mild-flavored honeys, up to 10 per cent, and still meet consumer acceptance. These strong-flavored honeys may be used in limited concentration in rye bread. Eight per cent buckwheat honey were used successfully.

Honey can be used advantageously in soft roll production in concentrations as high as eight per cent. The dark colored or strong-flavored honeys in any concentration are not recommended for roll production.

Proposed Specifications

As a result of the investigations on the use of honey in baked products, it has been possible to draw up certain specifications which should serve as a guide to those who offer honey for sale to bakers.

(a) All honey containers should be clearly labeled showing grade, floral source, moisture content and color in mm. Pfund as well as U. S. Department of Agriculture Color Standards.

(b) Honey for bakers' use should be U. S. Grade "A" or "B," according to U. S. Standards for Grades of Extracted Honey, effective April 16, 1951.

(c) The Pfund colorimeter reading should not exceed 70 mm. for honey used in white baked products.

(d) Predominant floral sources of buckwheat, fall flowers, heartsease, and horsemint should not be used except in blends of not more than 10 per cent with other mild flavored honeys.

(e) Honey should conform to Pure Food and Drug laws.

(f) Honey should be heated at 160° F. for 30 minutes to retard granulation and enzyme activity.

Cookie Production (3)

An almost endless variety of cookie formulas are available to the baker. The concentration of sugar in cookies is usually high and the use of honey presents many more problems and opportunities than the use of honey in bread products. The cookies which always sell well and which account for the majority of commercial cookie production include sugar cookies, ginger snaps, vanilla wafers, coconut macaroons, fruit bars, and brownies.

Table II

Chemical Analysis of honeys (3)

Floral Source	Moisture	Color[1]	Total Acidity[2]	Dextrose	Levulose	Sucrose	L/D[3]
	%	mm.	ml.	%	%	%	
Tupelo	15.9	44	18.7	28.2	43.8	2.4	1.55
Basswood	18.1	29	10.9	35.9	37.0	2.3	1.03
Heartsease	19.4	92	13.4	33.2	37.2	1.2	1.12
White thistle	15.9	41	25.8	33.7	39.6	5.0	1.17
Fall flowers	18.0	72	22.1	37.5	37.4	1.6	1.00
Mesquite	17.8	24	10.6	39.3	38.9	1.8	.99
Calif. alfalfa	15.6	60	26.5	37.5	39.0	4.7	1.04
Eucolyptus	16.6	57	14.2	36.2	41.6	1.5	1.15
Sweet clover	16.2	24	9.3	37.0	41.0	3.0	1.11
Ariz. alfalfa	16.2	58	15.1	37.0	41.8	1.5	1.13
Calif. buckwheat	13.4	56	21.5	36.3	42.3	0.9	1.16
Cotton	19.4	51	17.9	37.0	38.8	1.6	1.05
Orange	16.6	23	9.7	35.9	39.6	4.0	1.10
White clover	18.6	37	16.1	36.5	38.1	2.6	1.04
N.Y. buckwheat	17.5	121	23.0	38.8	39.0	1.7	1.01

[1] Mm Pfund
[2] Ml N/10 NOAH per 100 gm.
[3] Levulose-Dextrose ratio

Research was conducted to determine whether honey could be used to replace part or all of the sugar and whether the honey affected the typical characteristics of these cookie types. The cookie formulas are listed in **Table III.**

Sugar cookies, ginger snaps, and vanilla wafers, traditionally, are a brittle-type cookie. The quantity of honey that can be used in this type of cookie is limited by the tendency of honey to impart "chewy" or tough properties to the finished cookie. It was found that replacement of five per cent of the sucrose with honey was the upper limit of acceptability in sugar and vanilla wafer-type cookies. In ginger snaps, the concentration of honey could be increased to replace as much as 30 per cent of the sugar. It was interesting to observe the improvement in flavor and color of sugar cookies and vanilla wafers with the use of five and 30 per cent honey, respectively. These improvements in the cookie were associated with the browning reaction occurring between free reducing sugar and available amino nitrogen.

In the chewy-type cookie, high concentrations of honey were found to improve the quality of the cookies. Best results with the coconut macaroons were obtained using 13.3 per cent honey. With fruit bars, the quality of honey that could be successfully used was limited by the effect of moisture on the dough handling properties. It was found that 66 per cent honey caused the fruit bars to be chewy and to have a golden-brown color. The flavor of honey complemented the fruit and spice flavors. The optimum concentration of honey in brownies was 50 per cent. The brownies made with honey were chewy and the flavor and appearance were enhanced.

Different floral sources of honey may be used in cookie production. Consumer tests demonstrated that any mild flavored honey met with acceptance. Floral sources such as tupelo and eucalyptus are of doubtful value for cookie production and heartsease, fall flowers, horsemint, and buckwheat honey met with unanimous disapproval.

Table III

Cookie formulas

Sugar Cookies (g.)

Sucrose	58	Whole Egg	8
Shortening	27	$(NH_4)_2CO_3$	1
Salt	1.5	Water	18.5
Dry Skim Milk	2.5	Flour	100

Ginger Snaps (g.)

Sucrose	40	Molasses	45
Shortening	20	Invert Syrup	5
Dry Skim Milk	5	Water	8
Salt	1	$(NH_4)_2CO_3$	1.5
Ginger	1.5	Flour	100

Vanilla Wafers (g.)

Sucrose	30	Whole Egg	30
Powdered Sugar	30	Water	10
Shortening	35	$(NH_4)_2CO_3$	0.5
Invert Sugar	5	Cream of Tartar	0.5
Salt	1	$NaHCO_3$	0.5
Dry Skim Milk	10	Flour	100
		Vanilla	2

Coconut Macaroon Chips (g.)

Brown Sugar	86.6	Invert Syrup	13.3
Shortening	53.3	Water	20
Salt	1.5	Coconut	26.6
Dry Skim Milk	2.5	Flour	100
Baking Powder	1.5	Almond Flavor	0.5

Fruit Bars (g.)

Sucrose	66.6	Salt	1
Brown Sugar	33.3	Raisins	116
Shortening	33.3	Flour	100
Whole Eggs	33.3	$NaHCO_3$	1
		Cinnamon	1

Brownies (g.)

Sucrose	166	Whole Eggs	50
Shortening	83.3	Pecans	66.6
Glucose	50	Flour	100
Cocoa	33.3	Water	16
Salt	4	Vanilla	2

Cake Production (1), (2), (5)

The utilization of honey in cake production presented several problems that were different from those found in bread production. In bread production, if sucrose is used, it is converted to levulose and dextrose almost immediately when mixed with yeast. Hence, the sugar of honey is not fundamentally different in bread-making from sucrose. In cake production, however, sucrose remains essentially a non-reducing sugar and is, therefore, quite different in properties from the levulose and dextrose of honey. It was observed early in our research with cakes that unless the honey concentration was limited to about one third of the total sugar in the cake, undesirable browning of the crumb occurred with commitant development of burnt flavors. It was obvious that these flavors were associated with an intense browning reaction.

Much research effort (1) has been expended to study the nature of the products formed and to control the browning reaction in cake production where honey is the principal source of sugar. It is believed that if adequate means were devised to control the reaction, high concentrations of honey could be used in cake production. By use of high concentrations of honey, such desirable properties as retention of moisture and elimination of crumbliness of the cake crumb could be achieved.

The use of honey in cake caused loss in volume because of the premature reaction with the baking powder during mixing of the batter. The amount of soda in the cake formula can be increased to alleviate the volume loss. However, the browning reaction which affects both color and flavor of the cake is catalyzed by an alkaline reaction. It was observed that the browning reaction in cake did not occur until in the later stages of the baking process. The problem was then to determine the cause for the low volume and how it could be overcome while at the same time controlling the crumb color.

To show that loss of cake volume was due to premature reaction of soda with the acid of the honey, cake batters were mixed in a closed system so that the carbon dioxide escaping from the batter could be measured. The results of these ex-

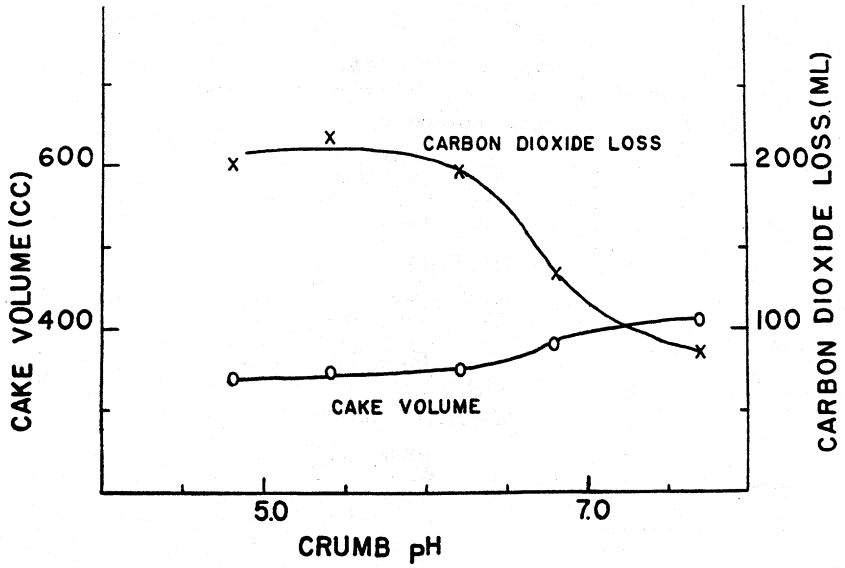

FIGURE 1: *Effect of cake batter pH on carbon dioxide cake volume losses.*

periments are shown in **Figure 1.** Cake volume increased as the pH of the batter was shifted to neutrality or above 7.0. The loss of carbon dioxide from the batter decreased as the cake volume increased. These experiments led to another step. It had been shown, if the acidity of the cake crumb could be maintained at approximately pH 6.3 during the final stages of the baking process, that the browning reaction could be controlled. Accordingly, potassium bitartrate was coated with a hard shortening that would melt and release the acid in the latter stages of baking. By this means the pH of the cake crumb was lowered near the end of the baking process and crumb browning was essentially controlled. The acid did not react with the baking soda because it was coated. Other acid leavening agents may be used. Glucono-delta lactone may be used with soda. The lactone rearranges in the later stages of the baking process providing acid to regulate the pH of the cake crumb.

Experiments have been performed in which 100 per cent honey was included in the formula and excellent quality cakes have been produced. Good floral sources of honey in high concentrations have been used to produce ginger, chocolate, and spice cakes. It would appear that a potential market for honey exists in these products.

Browning Reaction

The nature of the browning reaction products in cakes made with high concentration of honey has been investigated. A number of the products of the browning reaction have been extracted from cake crumb and separated by paper chromatography. One of these compounds which is believed to be one of the cardinal members in the pathway of the reaction has been isolated and is being studied. It is hoped, from knowledge of the compounds formed in the pathway of the browning reaction, that the reaction will be even more readily controlled than is now being done by regulation of the pH of the cake batter during the baking process.

Honey in Icings

The icing of pastries, cakes, and cookies is a common practice. In the United States, the consumer considers that the cake is not ready to eat until it is decorated with an icing. Use of a large proportion of honey and syrups in icing production creates certain problems. The addition of honey to icings requires the use of stabilizers in proper concentration. Furthermore, the ingredients must be added in a certain way. If a satisfactory icing of marshmallow and butter and fondant-type could be produced, the baking industry could take advantage of the desirable honey flavors.

Considerable research effort has been devoted to the development of icing formulas using high concentrations of honey. The following is an example of a satisfactory marshmallow-honey type icing:

200 g. honey
3 g. agar
1.5 g. gelatin
30 g. granulated sugar
60 g. water
30 g. egg white
0.2 g. citric acid
20 g. powdered sugar.

The honey was heated to 160° F. The gelatin and agar were blended with the sugar and then mixed with the water and boiled for one minute. After cooling to 160° F. the agar-sugar solution, honey, egg whites, citric acid and powdered sugar were combined and whipped to the consistency of marshmallow icing.

A number of different stabilizers were investigated. An example of the effect of various stabilizers is shown in **Figure 2.** These marshmallow icings had been stored for 12 hours. Gelatin proved satisfactory when used in concentration of 1½ grams. The agar stabilizer tended to produce a tender and fragile-type icing. Irish moss, gum arabic and guar gum tend to cause the icings to flow. When these icings were stored for more than 36 hours, they tended to dry and become tough. This was overcome by enrobing the icing with a fondant icing made by using 100 parts sugar, 5 parts honey and 15 parts of hot water.

Summary

Much effort has been devoted to discover how honey can best be utilized by the baking industry. In bread production the use of honey presents no serious problem with the possible exception of handling and costs. It imparts a richness of flavor to white and dark breads alike and may be used to replace sugar.

Honey can be used in cookie production. The quantity that can be incorporated in crisp-type cookies is limited but excellent flavors are imparted to these types by way of the browning reaction. In chewy-type cookies, honey may be used in relatively high concentration. Honey improves the texture and flavor of cookies like coconut macaroons, fruit bars, and brownies.

The use of honey in cakes presents several difficulties, which have been partially alleviated through research. Loss of cake volume and browning of the cake crumb can be controlled by the use of an agent that regulates the pH of the cake crumb in the later stages of the baking process. Much effort is being made to discover the pathway of the

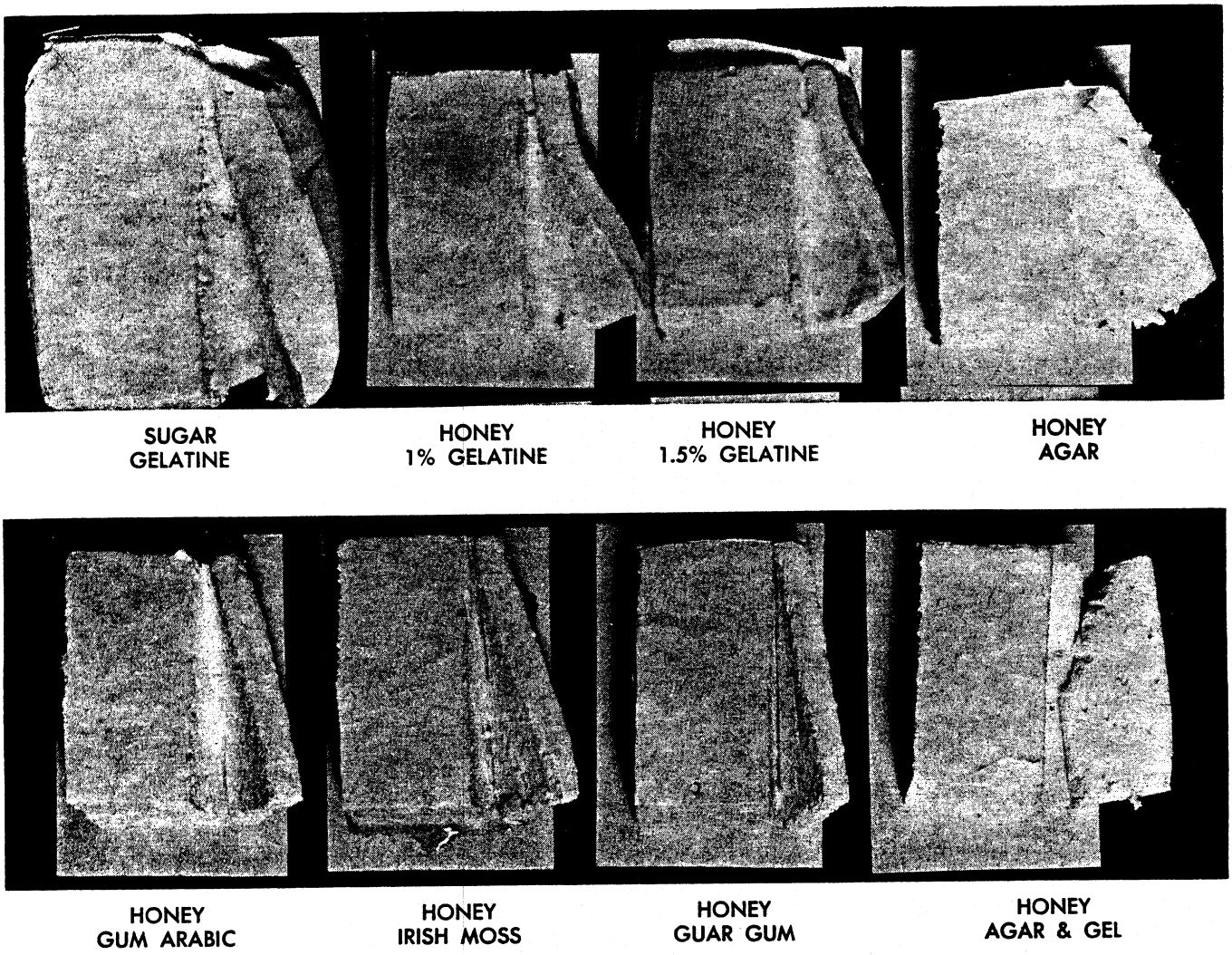

FIGURE 2: ***Honey-marshmallow icings made by using different stabilizers.***

browning reaction in cake so that an efficient means might be devised to control the reaction.

The delectable flavors of honey can be imparted to baked sweet goods by the use of icings in which honey is the major constituent. Marshmallow-type icings using honey have been developed.

Helpful suggestions from Dr. J. W. White, Jr. are gratefully acknowledged.

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THE END

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